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Working Paper Number	1981-006A
Creation Date	January 1981
Citable Link	https://doi.org/10.20955/wp.1981.006
Suggested Citation	Hafer, R.W., Hein, S.E., 1981; Investigating the Shift in Money Demand: An Econometric Analysis, Federal Reserve Bank of St. Louis Working Paper 1981-006. URL https://doi.org/10.20955/wp.1981.006

INVESTIGATING THE SHIFT IN MONEY DEMAND: AN ECONOMETRIC ANALYSIS

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81-006

We would like to thank Dallas Batten, Michael Bordo, Denis Karnosky, G. S. Laumas, Ed Offenbacher, Mack Ott, Doug Pearce, Bob Rasche, Warren Weber and William White for their helpful comments on an earlier version of this paper. The usual caveat applies. Jim Lamb provided able research assistance. Earlier versions of this paper were presented at the Federal Reserve Bank of Minneapolis and Washington University. The views expressed are those of the authors and may not represent those of the Federal Reserve Bank of St. Louis.

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I. Introduction

One of the most perplexing issues facing macroeconomists in general, and monetary economists in particular, is the breakdown of the conventional money demand relationship. Following Goldfeld (1976), a substantial amount of research has attempted to explain the empirical finding that the conventional equation significantly overpredicted real money balances after 1973. The equation which has become the focal point of this research effort is

$$\ln (M_t/P_t) = \delta_0 + \delta_1 \ln y_t + \delta_2 \ln RCP_t + \delta_3 \ln RCB_t + \delta_4 \ln (M_{t-1}/P_{t-1}) + \varepsilon_t, \tag{1}$$

where M is the narrow (M1) measure of money, P represents the implicit GNP deflator (1972 = 100), y is real GNP ($1972), RCP is the 4-6 month prime commercial paper rate and RCB is a weighted average of commercial bank passbook rates.

Research efforts have concentrated primarily on repairing this equation by incorporating variables thought to have been improperly excluded, or using alternative measures for the theoretical constructs which underlie this relationship (i.e., alternative measures of income and interest rates). One area of interest left unexamined is the question of the exact nature of the relationship's breakdown. In this paper we take the above specification as a given and seek to determine whether it has been subjected to a level shift, or if the marginal relationship actually has changed.

In the next section we briefly detail three alternative explanations of the breakdown. Special consideration is given to whether these explanations suggest an intercept or slope shift. A simple test procedure which differentiates between these two types of shift is presented in Section III. The fourth section applies this procedure to the above money demand specification; the evidence presented there allows us to reject the view that the marginal relationship has changed and, consequently, those explanations of the breakdown that are based upon such a shift. Section 5 considers more formally the level shifts that have taken place. A summary and concluding remarks are offered in the final section.

II. Competing Explanations of the Breakdown in Money Demand

There appear to be three broad classes of explanation of the breakdown in the conventional money demand relationship. One of the earliest explanations of the breakdown concentrated on the actual measurement and definition of money. It was argued that the narrowly defined M1 measure (currency plus demand deposits) no longer was an accurate measure of money. Garcia and Pak (1979 a, b), for example, argued that the widespread use of immediately available funds (IAFs) beginning in the early 1970s represented a significant financial innovation making the M1 measure obsolete. Porter, Simpson, and Mauskopf (1979) extended this argument by considering whether or not the introduction of money market mutual funds (MMMFs) also represented a significant financial innovation affecting the usefulness of the narrow monetary measure.

The important point to recognize from this paper's perspective is that if either of these arguments is correct, the breakdown in the estimated relationship will be of a marginal nature rather than a level shift. While the introduction of both of IAFs and MMMFs indeed represent a one-time innovation, the popularity of these assets has been increasing through time. Thus, if either of these assets should actually be incorporated in the money measure, improperly using a money measure that does not account for these changes should result in ever-increasing measurement errors. Allowing for a once-and-for-all intercept shift, therefore, will not be of any use in restoring the previously found empirical relationship.

We explicitly recognize that the M1 measure is no longer the best transactions measure of money in the empirical work reported in the next section . By adopting the new M1B measure, we acknowledge the importance of NOW (negotiable orders of withdrawal) and ATS (automatic transfer service) accounts as transaction deposits. No allowance for IAFs or MMMFs is made, however. Thus, if either of these financial innovations is actually functioning as money, the empirical investigation should indicate a breakdown in the marginal relationship. Although it is impossible to ascertain *a priori* which of the slope parameters will actually change, it is certain that allowing for an intercept shift will not reestablish the marginal relationships.

A second explanation of the breakdown concerns the impact of interest rates on desired money holdings. Porter, Simpson, and Mauskopf (1979) again offer an explanation. They argue that "high interest rates in 1973-74, 1978, and early 1979 have increased the incentive for managers to implement new cash-management techniques." In this view, interest rates are held responsible not only for the normal economizing of cash balances, but also cash-management innovations, The important point is that changes in cash-management techniques have been induced by changes in market interest rates. Eventhough no additional variable has been included directly in the conventional money demand equation to capture these innovations, none need be because the variable causing such changes (market interest rate) is already included. If the Porter, et. al. argument is correct, then the conventional equation is not misspecified, *per se*, but rather the equation has misbehaved because the interest elasticity of money demand is not stable. This point is explicitly recognized in their argument that "as short-term interest rates rise, there is a greater incentive to increase the use of cash-management activities so that the demand for money becomes more interest-elastic at higher interest rates."

This explanation of the breakdown in the money demand relationship clearly points to a change in the marginal relationship between real money balances and market interest rates. Specifically, the interest elasticity of money demand is held to be unstable. Allowing for an intercept shift, therefore, will not improve the performance of the conventional relationship if this explanation is correct.

An explanation of the breakdown in the money demand relationship which explicitly suggests a level shift in the conventional money demand specification is the view offered by Karnosky (1976). In his explanation a one-time, level shift in this relationship can be expected to follow the dramatic increase in energy prices occuring in early 1974. In his words, "So long as OPEC is willing to tolerate the reduced rate of oil production that their actions cause, the wealth of the United States and others is permanently decreased. One manifestation of this wealth loss is a one-shot decrease in the demand for real money balances." Because the conventional money demand equation does not include a variable to capture this one-time wealth loss, the relationship can be expected to exhibit a once-and-for-all level shift in early 1974. There is no reason, however, to expect the marginal relationship between real money balances and the other independent variables to change. Thus, the marginal relationship should be stable over the entire sample period.

Karnosky's view does not necessarily imply that the conventional specification was misspecified prior to 1974. As an empirical matter, the wealth effects which he stresses could easily have been captured by the real GNP variable prior to

1974. This is especially true when it is recognized that equation (1) can be rewritten as an infinite distributed lag on each of the independent variables with the lagged dependent variable excluded. The distributed lag of real GNP could have served as a good proxy for wealth prior to 1974, but could have been very misleading following the oil price shock.

III. A Test Procedure for an Intercept Shift vs. a Slope Shift

A straightforward procedure exists to test for an intercept, as opposed to a slope, shift. The procedure is to first-difference the original level specification and estimate this transformed equation. If the level relationship has been subject to only an intercept shift, the regression coefficients in the transformed equation (which does not include an intercept term) will remain stable. If, however, the <u>slope</u> coefficients in the level equation have shifted, the slope coefficients in the transformed (i.e., first-differenced) equation also will exhibit instability.

The merits of this procedure are exemplified by considering the simple linear relationship,

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t. \qquad (2)$$

Suppose equation (2) is believed to hold for $t=1, 2, \ldots, K$, while in fact an unforeseen intercept shift occurred at some point $t=T$ ($T<K$). The intercept term over the latter period is assumed to be $\beta_0' = \beta_0 + \delta$, where δ is a constant. The true model is represented, therefore, by the following two equations;

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t \qquad (t=1, 2, \ldots, T-1) \quad (3)$$

and

$$y_t = (\beta_0+\delta) + \beta_1 x_t + \varepsilon_t \quad (t=T, T+1,\ldots,K). \quad (4)$$

Estimating equation (2) using the first T-1, or the last K-T observations would yield ordinary least squares (OLS) estimators possessing all the desirable properties. Estimating equation (2) with all K observations, however, would yield biased coefficient estimates: The coefficient bias occurs because the δ-term is incorrectly omitted in the latter K-T observations.[1/] Because the full period slope coefficient estimate is biased, comparing these regression estimates from equation (2) with either subperiod would lead to the incorrect conclusion that the slope coefficient had changed.

Suppose, however, that the first-difference form of equation (2) is estimated. Such an approach has been suggested as a useful tool in examining the model's specification.[2/] The relationship believed to be correct is

$$Y_t - Y_{t-1} = \beta_1 (X_t - X_{t-1}) + \varepsilon_t - \varepsilon_{t-1} \quad (t=2,\ldots,K). (5)$$

In the presence of an unforeseen intercept shift, estimating the first-difference relationship will substantially diminish the bias in the estimated slope coefficient when all K observations are used. Specifically, if equations (3) and (4) are correct, the first-difference relationship in equation (5) will be accurate for all time except t=T, the point of the intercept shift. At time t=T, equations (3) and (4) indicate that the proper first-difference relationship is given by

$$Y_T - Y_{T-1} = \delta + \beta_1 (X_T - X_{T-1}) + \varepsilon_T - \varepsilon_{T-1} \qquad (6)$$

Comparing equation (6) with equation (5) for t=T, indicates that the δ-term again has been improperly excluded. The point to be stressed in considering the first-difference equation, however, is that the specification error occurs only at one point--the point of the intercept shift. On the other hand, estimating the level form of the relationship yields a specification error for all of the latter K-T observations. In this sense estimating the first-difference equation, in the face of an unknown intercept shift in the level relationship, will be subject to less bias in the estimated slope coefficient compared to the level-form estimate.[3/]

Estimating the first-difference relationship is not only econometrically superior in the face of a once-and-for-all intercept shift, but also is useful in differentiating between a slope shift and an intercept shift. For example, if the slope coefficient rather than the intercept term changed at time T (assuming a slope shift of ϕ), the following two equations accurately represent the true relationships,

$$Y_t=\beta_0+\beta_1 X_t+\epsilon_t \qquad (t=1, 2, \ldots, T-1) \quad (7)$$

and

$$Y_t=\beta_0+(\beta_1+\phi)X_t+\epsilon_t \qquad (t=T, T+1, \ldots, K) \quad (8)$$

Accordingly, the true first-difference relationship for the full sample $t=1, \ldots, K$ is given by

$$Y_t-Y_{t-1}=\beta_1(X_t-X_{t-1})+\epsilon_t-\epsilon_{t-1} \qquad (t=1, 2, \ldots, T-1), \quad (9)$$

$$Y_t-Y_{t-1}=\beta_1(X_t-X_{t-1})+\phi X_{t-1}+\epsilon_t-\epsilon_{t-1} \qquad (t=T) \quad (10)$$

and

$$Y_t-Y_{t-1}=(\beta_1+\phi)(X_t-X_{t-1})+\epsilon_t-\epsilon_{t-1} \qquad (t=T+1, T+2, \ldots, K). \quad (11)$$

Equations (9) through (11) illustrate that if the difference in

Y_t is regressed against the difference in X_t, as shown in equation (6), the estimated slope coefficient depends upon the period estimated. Subjecting the first-difference relationship to an analysis of coefficient stability given a slope shift in the level specification would indicate that the slope coefficient is unstable in the first-difference specification. In contrast, if the original level relationship is subjected to a once-and-for-all intercept shift, the first-difference estimate of the slope coefficient will be stable.

The gain from considering the stability of the first-difference relationship vis-a-vis the original level relationship is that the former does not include a direct counterpart to the intercept term in the level relationship. Given a shift in the intercept term of the level relationship, an analysis of the level relationship's stability will indicate structural instability. It will be impossible from this analysis alone, however, to determine whether the intercept or the slope coefficient shifted. A natural step in this regard is to estimate the first-difference relationship and subject the coefficient estimates from that equation to a stability analysis. If an intercept shift occurred in the level relationship, the first-difference relationship will be statistically stable. On the other hand, if the slope coefficient in the level relationship has changed, both the level and the first-difference relationships will indicate a structural break.

IV. Estimation Results

This section presents the empirical results obtained from estimating both the log-level and first-difference forms of equation (1). The case for the existence of intercept shifts, as opposed to changes in the estimated slope coefficients, is examined through the use of post-sample predictions and a formal test for structural stability. Before turning to these discussions, however, it is necessary to comment on the estimation procedure used to obtain log-level coefficients.

When equation (1) was estimated for the period 1960/I-1973/IV using OLS, evidence of significant first-order serial correlation in the residuals existed. Previous estimations of equation (1) have relied upon utilizing the Cochrane-Orcutt iterative technique to correct for this problem. Given the presence of a lagged dependent variable and autocorrelated errors, however, this procedure will yield coefficient estimates that are both biased and inefficient.[4/] To properly correct for first-order serial correlation, we employ Hatanaka's (1974) residual-adjusted Aitken estimator. This procedure has been shown to yield coefficient estimates that are both unbiased and asymptotically efficient.[5/]

The 1960/I-1973/IV sample period estimates of equation (1) employing the Hatanaka estimation procedure and OLS estimates of the first-difference form of equation (1) along with key summary statistics are presented in table 1.[6/] The regression results indicate that the estimated coefficients on income and the commercial paper rate have the anticipated signs and are significantly different from zero at the 5 percent level. In the first-difference regression, however, the estimated coefficient on the commercial bank passbook rate variable is not statistically significant at the 5 percent level (two-tailed test). Although the estimated coefficients are roughly similar between the two relationships, some noticeable differences exist. The estimated speed of adjustment derived from the log-level equation, for example, is 22 percent per quarter compared to 44 percent from the first-difference equation. Because of this discrepancy, the estimated long-run income elasticity is 0.57 for the level equation, compared to 0.42 for the difference equation. Each of these estimates is, however, close to the theoretical value derived from the square-root formula.

The regression results in table 1 are used to statically simulate their respective dependent variables over the period 1974/I-1979/IV.[7/] The forecast error pattern and the summary evidence concerning each equation's predictive abilities provide useful information on the stability issue. Key summary statistics as well as a listing of the errors generated from simulating the level and first-difference forms of equation (1) are reported in table 2. The error pattern indicates, as Goldfeld originally found, that the log-level equation continually over-predicts real money balances throughout the post-sample period. These one-sided simulation errors are not evident, however, when the first-difference form of equation (1) is used.

The problem of one-sided prediction errors in the level relationship is further exemplified by the Theil decomposition statistics.[8] The coefficient U^M indicates that over 80 percent of the simulation error from the log-level equation is due to bias. The bias statistic reported for the first-difference forecasts, however, indicates that much of the problem has been alleviated; only about 7 percent of the first-difference forecast error is due to bias. A further comparison can be made on the basis of the covariation statistic (U^C). Finding that 72 percent of the error in the first-difference forecasts is caused by covariation whereas only 11 percent of the log-level error is due to covariation further exemplifies the general stability of the first-difference equation.

Another indication of the first-difference equation's relative stability is provided by comparing the equations' estimated standard errors for the 1960/I-1973/IV period to the out-of-sample root-mean-squared-errors (RMSE). For example, the in-sample standard error estimated for the log-level equation is 0.0040, whereas the RMSE is 0.0178--a value four times the in-sample error. The comparison for the first-difference equation suggests a much more stable relationship: The estimated standard error of the equation is 0.0046 while the RMSE is 0.0068, a value well-within two standard errors of the in-sample error variances. On statistical criteria, therefore, the post-sample simulation errors generated by the first-difference specification are not distinguishable from the in-sample errors.

The inference that the first-difference specification is stable, while the log-level equation has shifted, is supported by the full 1960/I-1979/IV sample period regression results reported in table 3. Comparing the full-sample log-level results with those obtained for the earlier sample period (1960/I-1973/IV) indicates that, while the estimated coefficients on the commercial paper rate and the commercial bank passbook rate are similar in magnitude for the two alternative sample periods, the estimated short-run income elasticity is about one-half the previous estimate (.057 versus .125). Moreover, the estimated speed of adjustment of actual to desired real money balances is 4 percent for the full sample compared to 22 percent in the earlier period. Finally, the estimated coefficient on the commercial bank passbook rate variable is insignificantly different from zero at the 5 percent level.

Examining the full period estimation results for the first-difference relationship suggests insignificant variation in the estimated coefficients.[9/] The estimated speed of adjustment for the earlier sample period and the full period is about 44 percent per quarter. The equation's explanatory power in both periods is approximately equivalent and again there is no evidence of first-order serial correlation among the residuals. The marked change in the coefficient estimates (as well as the overall in-sample fit) observed for the log-level equation no longer is evident.

Chow tests were employed to formally examine the stability of the two relationships. The null hypothesis is that all the estimated regression coefficients in each relationship remained unchanged over the full sample period. The breakpoint considered is 1973/IV. To reiterate, evidence that does not permit rejection of the null hypothesis for the first-difference equation while rejecting the null for the level relationship points to the instability in the log-level specification as arising from an intercept shift.

The calculated F-statistics for the Chow test are presented in table 4. The F-statistic for the log-level equation exceeds the 1 percent critical value indicating a statistically significant change in the equation's structure. In sharp contrast to this finding is the evidence for the first-difference equation: the F-value calculated for this specification does not exceed any reasonable critical value, supporting the notion that the first-difference equation indeed has remained statistically stable over the 1960/I-1979/IV sample period.

The evidence presented in this section indicates that the first-difference money demand equation has not undergone the structural change observed in the log-level relationship. This finding, in conjunction with the discussion of Section III, is fully consistent with the hypothesis that the log-level short-run money demand equation has been subject to a once-and-for-all shift in the intercept term.

V. A Direct Test for Intercept Shifts

Even though finding a stable first-difference money demand specification indicates stability in the marginal relationships and an unstable constant term in the level equation, a useful exercise is to locate the most likely shift point. This exercise is important because Karnosky's explanation of the shift in money demand suggests the shift will closely follow the significant increases in energy prices in 1974. Thus, the timing of this hypothesis can also be considered.

The discussion in Section III indicates that, at the time of a once-and-for-all intercept shift in the level specification, an unusually large residual will occur if the first-difference equation is estimated. Consequently, examination of the residuals obtained from the first-difference equation provides a useful diagnostic procedure to locate and test for intercept shifts in the level equation.

The estimated residuals from the first-difference equation for the full 1960/I - 1979/IV sample period, along with bounds set at plus and minus two standard errors of the first-difference regression equation, are plotted in figure 1. Examination of these residuals reveals that three exceed the two-standard-error bounds: 1974/II, 1975/IV and 1979/II. With the exception of 1979/II, the residuals are negative, suggesting "downshifts" in the log-level money demand equation.

A direct test for intercept shifts in the log-level specification was made by employing (0, 1) intercept dummy variables in the original log-level equation with the periods 1974/II, 1975/IV and 1979/II chosen as the possible shift points. The dummy variables were constructed in the manner:

	D1 =	1	1960/I - 1974/I,
		0	otherwise
	D2 =	1	1974/II - 1975/III,
		0	otherwise
	D3 =	1	IV/1975 - 1979/I
		0	otherwise
and	D4 =	1	1979/II - 1979/IV
		0	otherwise.

To test for the significance of these shift terms, the log-level specification was modified to include a constant term plus the dummy variables D1, D2 and D3. Consequently, the reported constant term represents the intercept for the 1979/II - 1979/IV period. To find the intercept's value for the other periods, the estimated coefficients for D1, D2 or D3 are added to the constant term estimate. The outcome of estimating this altered log-level equation is found in table 5. Once again, the sample period is 1960/I - 1979/IV and the Hatanaka estimation procedure is used.

The regression results for the log-level specification presented in table 5 are markedly different than those reported in table 3. In fact, except for a slightly larger estimate of the coefficient on the lagged dependent variable, the results in table 5 are directly comparable to the full-period first-difference results in table 3. For example, the estimated speed of adjustment based on the first-difference equation is about 44 percent per quarter; the relevant value for the adjusted log-level equation is about 38 percent--a much quicker estimated speed of adjustment than the 4 percent value found for the equation in table 3. Properly accounting for the hypothesized shift in the intercept, as indicated in table 5, has yielded a log-level equation that does <u>not</u> reveal a breakdown in the marginal relationships between real money balances and income and interest rates.

The question to be addressed now concerns the significance of these alternative shifts. To test the statistical significance of the intercept shift variables, standard t-tests were employed. The test results indicate that <u>only</u> the 1974/II intercept shift is significantly different from the other shift terms at the 5 percent level. The upshot of this finding is that, of the three intercept shifts examined, <u>only</u> the intercept shift that occurred in 1974/II is statistically significant.

To further investigate the impact of this finding, the log-level equation is reestimated using only the 1974/II intercept shift variable. These regression results, presented in table 6, again support the contention that the marginal relationships embodied in the short-run money demand equation have not changed, but that the equation was subject to a significant downward, <u>level</u> shock in 1974/II. Indeed, the results from table 6 indicate that the constant term of the log-level specification decreased from -0.709 to a value of -0.722 in 1974/II. The timing of this level shift is totally consistent with Karnosky's one-time wealth loss argument.

VI. Summary and Conclusions

This paper has examined the issue of money demand instability by testing three competing hypotheses of the alleged breakdown. Two of the hypotheses--one that money should be defined more broadly to include IAFs and MMMFs and the other that recent interest rate movements have given rise to demand reducing cash management techniques--suggest a change in the marginal relationship between real money balances and income and interest rates. A third hypothesis, which derives from the 1974 oil price increase and the economy's concomitant wealth loss, suggests a change, not in the marginal relationships embodied in the conventional money demand equation, but in the function's level. These hypotheses were tested by using a first-difference specification of the money demand equation.

The empirical results presented in this paper support the contention that the money demand equation was subject to a level, not marginal, shift in early 1974. Based on our analysis of the first-difference results and the properly specified log-level equation, we find that 1974/II is the most likely point of the downward shift in the function. This finding indicates that we may reject those hypotheses suggesting changes in the marginal relationships. We may <u>not</u>, however, reject the hypothesis that the economy suffered a one-time wealth loss in early 1974, and a resulting once-and-for-all decrease in the level of the demand for real money balances.

A major implication of this study is that the usefulness of the short-run money demand equation for policy analysis and prescription has not vanished. The marginal relationships, as we have shown, have in fact remained stable throughout the turbulent post-1973 period. Clearly, then, the blame for missing monetary growth targets cannot be laid at the door of an elusive, unstable money demand function.[10/] Rather, our empirical evidence suggests that the cause of such errors must be found elsewhere.

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FOOTNOTES

1/ Excluding a relevant variable, in this case the intercept shift term δ, biases not only the β_0 and β_1 coefficient estimates, but also the estimate of the residual variance. On this point, see Maddala (1977), pp. 155-57.

2/ The increased awareness of the usefulness of first-differencing is exemplified in the articles by Granger and Newbold (1974), Plosser and Schwert (1977, 1978) and Williams (1978).

3/ See Maddala, op. cit.

4/ See Theil (1971), pp. 413-14. It has been shown also that the Cochrane-Orcutt procedure may not iterate to a global minimum of the regression standard error. See, Hafer and Hein, 1980.

5/ For a complete discussion of the procedure, see Hatanaka (1974). Only recently has this procedure been used in money demand studies. See, for example, Lieberman (1980), and Laumas and Spencer (1980).

6/ A possible problem arising from first-differencing the level equation is the existence of an error structure with higher order serial correlation than unity. On the belief that this order was not greater than two and noting that the reported regression results indicate no evidence of first-order serial correlation, a second-order transformation was applied to the first-difference equation. This approach did not appreciably alter the conclusions reached in the paper. Thus, we have chosen to report the more widely understood OLS estimates of the first-difference specification.

7/ For those familiar with the recent money demand literature, it may be surprising to find <u>static</u> rather than <u>dynamic</u> forecasts employed. Hein (1980) shows that the latter technique yields a biased measure of the shift in a relationship. Consequently, the more widely understood static forecasting procedure is employed in this paper.

8/ For a complete description of the derivation and interpretation of the Theil coefficients, see Theil (1971), pp. 27-32.

9/ The relatively large change in the estimated standard error of the equation between the two sample periods suggests the presence of heteroskedastic errors. Performing a test for heteroskedasticity developed by White (1980) indicates that the null hypothesis of no heteroskedasticity cannot be rejected at the 5 percent significance level. The calculated chi-square statistic is $X(10 \text{ d.f.}) \doteq 10.29$.

10/ An alternative viewpoint may be found in Axilrod and Lindsey (1980).

Table 1
Short-Run Money Demand Regression Results
Log-Level and First-Difference Estimates: 1960/I-1973/IV

Specification	Coefficient[a] Constant	y_t	RCP_t	RCB_t	M_{t-1}/P_{t-1}	Summary statistics[b] $\bar{R}^2$/SEE($x10^{-3}$)	Durbin h-statistic rho
Log-level	-0.610	0.125	-0.016	-0.032	0.778	0.967	1.78
	(2.82)	(2.69)	(3.02)	(2.08)	(6.02)	3.96	0.309
First-difference	—	0.185	-0.015	-0.038	0.565	0.456	1.29
		(3.14)	(2.40)	(1.89)	(5.07)	4.62	—

a. All variables enter logarithmically or in first-difference in logs. The log-level equation is estimated using Hatanaka's (1974) procedure. First-difference estimates are based on OLS regressions. The numbers in parentheses are absolute values of t-ratios.

b. $\bar{R}^2$ is the coefficient of determination corrected for degrees of freedom, SEE is the standard error of the estimated equation and rho is the Hatanaka estimate of the autocorrelation coefficient.

Table 2
Post-Sample Static Simulation Results: 1974/I-1979/IV

Year and Quarter	Log-level specification Forecast error ($x10^{-2}$)[a]	First-difference specification Forecast error ($x10^{-2}$)[b]
1974/I	0.025	0.50
II	-1.28	-1.16
III	-1.29	-0.65
IV	-1.60	-0.70
1975/I	-2.28	-1.00
II	-0.68	0.90
III	-1.32	-0.31
IV	-2.51	-1.31
1976/I	-1.32	0.47
II	-1.30	0.34
III	-2.22	-0.73
IV	-1.75	0.11
1977/I	-1.48	0.26
II	-2.25	-0.55
III	-1.85	0.10
IV	-1.36	0.58
1978/I	-1.49	-0.13
II	-2.41	-0.91
III	-1.86	0.14
IV	-2.26	-0.41
1979/I	-2.66	-0.67
II	-1.21	1.16
III	-1.49	0.22
IV	-2.31	-0.70
Summary statistics:[c]		
RMSE	1.782 ($x10^{-2}$)	0.679 ($x10^{-2}$)
U^M	0.882	0.066
U^S	0.010	0.217
U^C	0.109	0.718

a. The forecast errors (actual less predicted) are logs of M1B (billions of $1972). They are obtained from simulating equation (1) and based on coefficient estimates reported in Table 1.

b. The forecast errors are in terms of growth rates of real M1B money balances. They are obtained from simulating equation (2) and based on coefficient estimates reported in Table 1.

c. RMSE is the root-mean-squared error in terms of real money balances (billions of $1972) for the log-level specification and in terms of growth rates for the first-difference specification. U^M is the Theil bias coefficient, U^S the variance coefficient and U^C the covariance coefficient. For an explanation of these statistics, see Theil (1971).

Table 3
Short-Run Money Demand Regression Results
Log-Level and First-Difference Estimates: 1960/I-1979/IV

Specification	Coefficient[a] Constant	y_t	RCP_t	RCB_t	M_{t-1}/P_{t-1}	Summary statistics[b] $\bar{R}^2$/SEE($\times10^{-3}$)	Durbin h-statistic /rho
Log-level	-0.275	0.057	-0.019	-0.039	0.962	0.874	-0.869
	(2.35)	(2.51)	(3.45)	(1.79)	(13.55)	5.27	0.553
First-difference	—	0.190	-0.017	-0.038	0.562	0.448	-0.472
		(3.51)	(2.94)	(1.68)	(5.70)	5.39	—

a, b. See notes accompanying table 1.

Table 4
Stability Test Results
1973/IV Break Point

Specification	F-value
Log-level	4.51
First-difference	0.06

Notes: The calculated F-values are based on the Chow test. Critical values for the log-level specification are 3.07 and 2.23 at the one and five percent significance levels, respectively. The appropriate values for the first-difference equation are 3.60 at the one percent level and 2.50 at the five percent level.

Table 5
Short-Run Money-Demand Regression Results
Log-Level Estimates Including Intercept Shift Variables
1960/I-1979/IV

Dependent variable	Coefficients[a]								Summary statistics[b]	
	Constant	$D1_t$	$D2_t$	$D3_t$	y_t	RCP_t	RCB_t	M_{t-1}/P_{t-1}	$\bar{R}^2$/SEE($\times 10^{-3}$)	Durhin h-statistic/rho
M1B	-0.881	0.016	0.003	-0.002	0.181	-0.019	-0.032	0.623	0.951	0.617
	(5.12)	(3.06)	(0.83)	(0.61)	(5.01)	(4.11)	(2.00)	(6.19)	4.36	0.451

a. All variables enter logarithmically except the constant and the variable D1, D2 and D3. Numbers in parentheses are absolute values of t-statistics. Hatanaka's estimation procedure is used.

b. $\bar{R}^2$ is the coefficient of determination corrected for degrees of freedom, SEE is the standard error of the estimated equation and rho is the final estimate of the autocorrelation coefficient.

Table 6
Short-Run Money-Demand Regression Results
Log-Level Estimates Including 1974/II Shift Variable

Dependent variable	Coefficient[a]						Summary statistic[b]	
	Constant	D1	y_t	RCP_t	RCB_t	M_{t-1}/P_{t-1}	$\bar{R}^2$/SEE($\times 10^{-3}$)	Durbin h-statistic/ rho
M1B	−0.722	0.013	0.148	−0.018	−0.027	0.700	0.944	−0.215
	(5.13)	(4.23)	(5.09)	(4.04)	(1.67)	(8.01)	4.42	0.436

a, b, see notes accompanying table 5.

Figure 1

Residuals Plot:
First-Difference Money Demand Equation